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THE EUROPEAN BROWN SNAIL IN CALIFORNIA

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HISTORY AND DISTRIBUTION

The European brown snail (*Helix aspersa* Müller) was described from Italy by Müller⁽⁵⁾ in 1774. It has followed man in his migrations, either through direct effort by man to introduce it into new localities because of its use as an article of food, or by being accidentally transported on plants, until it is now widely distributed in the temperate zones, and also occurs in several tropical localities.

In 1888, Tryon⁽⁸⁾ records the presence of the snail in southern and western Europe, England, Syria, northern Africa, the Canaries, the Azores, Madeira, Brazil, Argentine, Chile, Guiana, Cape of Good Hope, Mauritius, New South Wales, New Zealand, Haiti, and Cuba. In North America, W. G. Binney⁽²⁾ reported in 1869 that it was found in Charleston, South Carolina; New Orleans, Louisiana; Portland, Maine; and Nova Scotia, Canada.

The earliest record of the occurrence of *Helix aspersa* in California is of its discovery in Santa Barbara in 1850 by Kellett and Wood,⁽³⁾ who collected specimens in that locality while on a surveying expedition.³

According to Stearns⁽⁷⁾ it was brought to San Jose between 1850 and 1860, for he writes in 1900 that *Helix aspersa* was intentionally introduced or 'planted' in California over forty years earlier by A. Delmas of San Jose, Santa Clara County, who brought the stock from France and turned it out among the vineyards on the west bank of the Guadalupe. He states further that Delmas later also 'planted' colonies of the same snail in San Francisco and Los Angeles. In addition to the above localities, Stearns records its presence in 1900 in Oakland, Pacific Grove, and East Side and Elysian Parks in Los Angeles. Thus we see that even thirty years ago *Helix aspersa* was rather widely distributed in California. Now it is found in most of the cultivated districts of California from San Diego County to Sonoma County.

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³ Stearns⁽⁶⁾ thinks this record is an error due to mistaken determination.

DESCRIPTION AND CLASSIFICATION

This snail is a member of the family Helicidae belonging to the order Pulmonata, which comprises the terrestrial, air-breathing mollusks. The specific name *aspersa* means besprinkled and is somewhat descriptive of the coloration of the shell, which is a mixture of grayish-yellow and brown. The brown is not only sprinkled generally over the shell, but is also ordinarily concentrated into five interrupted bands. The second and third bands are usually confluent, so that there are in reality only four bands, one of which is considerably wider than the others (fig. 1). The variation in marking ranges from



Fig. 1.—Typical banding of *Helix aspersa* showing bands 2 and 3 united to form a single wide band.

individuals with typical banding, as described above, to those having all of the bands united and thus showing no separate bands at all. The one on the left in figure 3 is a good example of this. The shell is obliquely striate and finely malleate, i.e., covered with little depressions and ridges (fig. 2). Full-grown shells have from four to four and a half whorls, and are an inch or more in diameter. The form of the shell is that of a dextral, or right-hand spiral, but very rarely a sinistral, or left-hand spiral, is found (fig. 3).

The body is light to dark gray and when fully extended is about 2 inches long. The diagram in figure 4 shows the external anatomical

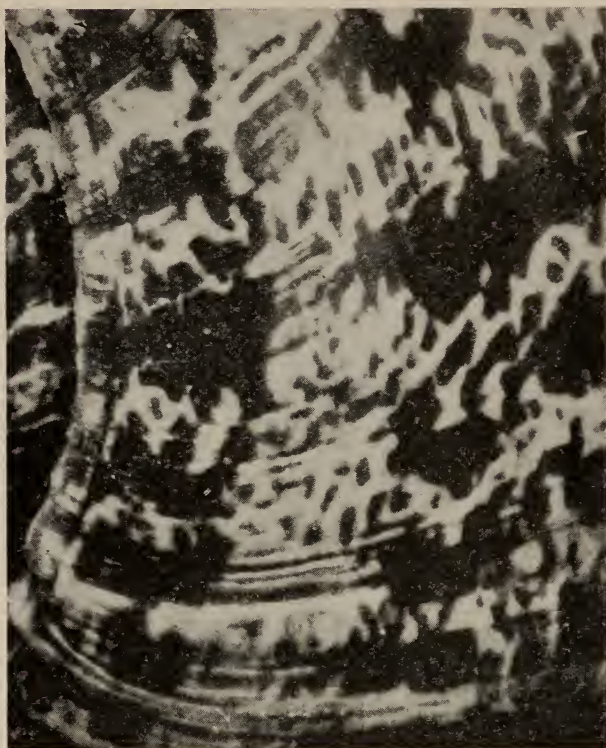


Fig. 2.—A section of shell enlarged about 64 times to show the striations and color mixture of brown and yellow.

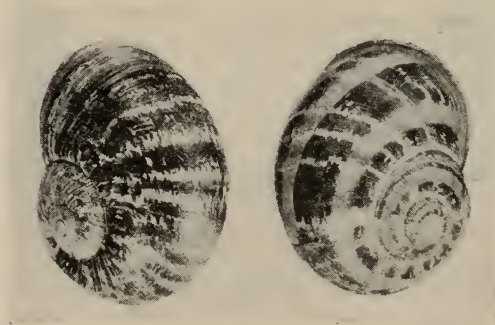


Fig. 3.—The specimen on the left, which was collected at Anaheim, California, in August, 1930, is a sinistral form. It also has all of the brown bands united into a single broad band. The specimen on the right is a dextral form and represents the usual coloration. (Natural size.)

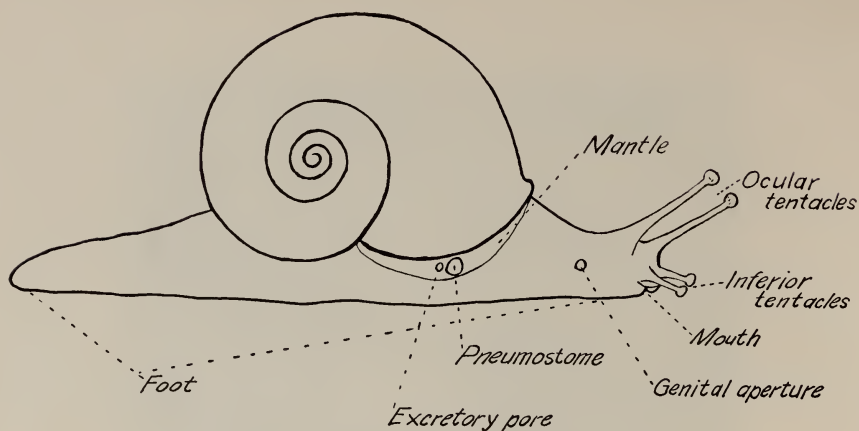


Fig. 4.—Diagram showing the external anatomical features.

features. The head is provided with two pairs of retractile tentacles. The ocular tentacles, the upper and larger pair, possess dark pigmented spots at the tips, which serve as eyes. The lower or smaller tentacles are very sensitive to touch, but their function is not definitely known. The mouth is surrounded by fleshy lips. On the upper



Fig. 5.—Jaw of *Helix aspersa*. (Enlarged about 156 times.)

part of the mouth just inside the lips, there is a small, hard chitinous jaw (fig. 5), to the upper edge of which muscles are fastened. The free, sharp edge is toothed and is used to cut or scrape off particles of food, or to aid in conveying food into the esophagus. On the lower side of the mouth cavity, there is a ribbon-like 'tongue', known as the radula, or odontophore, covered with minute tooth-like tubercles.

During the process of feeding, the radula has a constantly inward-working motion in conjunction with the jaw, so that between the radula and the jaw a fairly good grip can be secured on an object. The long, flat, muscular organ extending along the whole under side of the body is known as the foot. The snail glides along by means of an undulating motion of the muscles of the foot over a slippery track of mucus which is constantly secreted by glands in the foot while the snail is moving.

The mantle is a muscular sheet covering the upper part of the body and lying next to the shell. It not only secretes the material of which the shell is made, but also forms a cavity which serves as a lung in carrying out the respiratory function. In the mantle at the edge of the mouth of the shell is an aperture (the pneumostome) which opens into the mantle cavity for the admission of air. The excretory pore, connecting with the alimentary tract, is just to one side of the pneumostome. The genital aperture is on the side of the body near the head.

LIFE HISTORY AND DEVELOPMENT

These snails are hermaphroditic, each individual possessing both male and female organs. During mating, mutual fertilization takes place and both individuals may lay eggs. Mating requires from 4 to 12 hours, and begins during the night, but snails are often seen in coition in the morning because the process of fertilization was not completed before the appearance of day.

Oviposition usually occurs within 3 to 6 days after fertilization. A fertile snail selects a spot where the soil is damp and not too tightly packed, and begins preparing a nest for the eggs. The ground is scraped away with the mouth-parts and the loose soil is worked back underneath the foot. The undulations of the muscles of the foot serve as a kind of endless belt in moving the loose soil back out of the way. By this process, requiring several hours for completion, a hole $\frac{1}{4}$ inch or more in diameter and 1 to $1\frac{1}{2}$ inches deep is finally made, with a rounded cavity at the bottom $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in diameter for the egg mass. Figure 6 shows a nest and eggs of the white snail (*Helix pisana*) which, except for being smaller, are very similar to those of the European brown snail. As the genital opening is near the anterior end, the snail does not withdraw from the egg cavity until all of the eggs are laid. The eggs are laid singly but adhere to each other, forming a rather loose mass when the oviposition is completed.



Fig. 6.—Nest and eggs of *Helix pisana*. Except for being smaller, these are similar to the nest and eggs of *Helix aspersa*. (About natural size.)

TABLE 1

NUMBER OF EGGS LAID AT EACH OVIPOSITION

Number	Locality	Date	Eggs found in	Number of eggs
1	La Jolla	August, 1922	Flower pot	101
2	Whittier	September, 1923	Sawdust mulch	74
3	Fullerton	March, 1927	Orange grove	73
4	Fullerton	March, 1927	Orange grove	101
5	Fullerton	March, 1927	Orange grove	33
6	Fullerton	April, 1927	Orange grove	61
7	Rivera	June, 1927	Orange grove	102
8	Rivera	June, 1927	Orange grove	88
9	Rivera	June, 1927	Orange grove	110
10	Fullerton	June, 1927	Orange grove	119
11	Fullerton	June, 1927	Orange grove	106
12	Fullerton	June, 1927	Orange grove	80
13	Fullerton	June, 1927	Orange grove	81
14	Fullerton	June, 1927	Orange grove	105
15	Fullerton	June, 1927	Orange grove	86
16	Fullerton	June, 1927	Orange grove	69
17	Fullerton	June, 1927	Orange grove	47
18	Fullerton	June, 1927	Orange grove	87
19	Fullerton	June, 1927	Orange grove	97
20	Fullerton	August, 1927	Orange grove	112

Average

86.6

They are white, spherical, and about $\frac{1}{8}$ inch in diameter. The number of eggs laid during each oviposition varied in 20 egg masses, as noted in table 1, from 33 to 119, with an average of 86.

When the snail has finished ovipositing, it spends considerable time in closing the opening of the nest and concealing its location. By working in a circular fashion and mixing soil with mucus, the opening to the cavity is closed to a depth of perhaps $\frac{3}{8}$ of an inch, and often as a final effort in concealing the nest, a quantity of excrement is placed on top, and the operation of nest-making and oviposition is completed. A snail beginning to dig its nest during the night may be occupied all of the following day with the entire procedure of nest-making and egg-laying.

The frequency of ovipositions is subject to temperature, humidity, and soil conditions. Low temperature and low humidity inhibit the

TABLE 2

MATINGS AND OVIPOSITIONS OF FIVE PAIRS AT FULLERTON, 1929

Pair No.	Time	Days	Matings	Ovipositions	Eggs laid by each snail*
1	June 9-August 31.....	83	3	4	172
2	June 11-October 20.....	131	6	5	215
3	June 11-September 8.....	89	5	4	172
4	June 12-November 3.....	144	11	9	387
5	June 14-October 9.....	118	5	3	129

* Calculated on the basis of an average of 86 per oviposition.

activity of the snail, and dry soil is unsuitable for the preparation of a nest. During warm, damp weather, ovipositions may be as frequent as once a month. The record of the matings and ovipositions of 5 pairs of snails kept in outdoor cages for a period of several months is given in table 2.

The record of pair No. 1 is given in greater detail in table 3; it will be noted that no eggs were laid following the mating on June 9. This may have been due to disturbance, as the pair was taken while in coition and placed in the study cage on that date. If the first mating is disregarded, then pair No. 1 mated and oviposited twice during the 34 days between July 28 and August 31. In this period, if we take 86 as the average number of eggs at each oviposition, together they laid 344 eggs or 172 eggs each. Pair No. 4 laid 9 egg masses from June 12 to November 3, or nearly 1 egg mass a month. This pair laid approximately 774 eggs, or 387 each, during this time.

The reproductive period in the coastal areas of southern California is mostly confined to the time from February 1 to October 1. Low humidity and cold temperatures greatly inhibit the activity of the snails during the fall and winter months. If each individual is capable

TABLE 3
INDIVIDUAL RECORD OF MATINGS AND OVIPOSITIONS OF PAIR No. 1
AT FULLERTON, 1929

Date	Snail A	Snail B
June 9	Mating*	Mating*
July 28	Mating	Mating
August 1	Digging egg cavity	_____
August 2	Nest completed and eggs laid	Digging egg cavity
August 3	_____	Nest completed and eggs laid
August 14	Eggs hatched; young still in nest; incubation 12 days	Eggs not hatched
August 17	Young mostly left nest last night	_____
August 18	_____	Eggs just hatched; incubation 15 days
August 20	_____	Young left nest
August 25	Mating	Mating
August 27	Started nest but did not complete it	_____
August 29	Started nest again	_____
August 30	Nest completed; eggs laid	Making nest
August 31	_____	Nest completed; eggs laid
September 17	Eggs hatched several days and young mostly out of nest	Eggs hatched several days and young mostly out of nest

* No ovipositions followed the first mating. This may have been due to disturbance as the pair was taken in coition and placed in the study cage at that time.

TABLE 4
INCUBATION PERIOD OF EGGS LAID AT FULLERTON BETWEEN
JUNE 11 AND OCTOBER 19, 1929

Eggs laid	Hatched	Time, days	Eggs laid	Hatched	Time, days
June 11	June 30	19	September 2	September 17	15
June 27	July 11	14	September 15	September 30	15
July 1	July 11	10	October 2	October 16	14
August 2	August 14	12	October 9	October 27	18
August 14	August 25	11	October 19	November 9	21

of laying eggs once every 6 weeks during the 8 months from February to October, then approximately 5 ovipositions are made each year and 430 eggs laid. This seems to be a reasonable estimate for ordinary conditions. Thus it is evident that under favorable conditions, enormous numbers can be produced in a short time.

The time required for the eggs to hatch (table 4) is dependent on the temperature and no doubt on the dryness of the soil in which

the eggs are placed. During ordinary summer weather, the eggs hatch in about 2 weeks, but this time may be shortened somewhat during the warmer part of the summer or lengthened during the cooler seasons.

The young snails (fig. 7) are provided with a shell of somewhat more than one whorl at the time of hatching, and apparently differ



Fig. 7.—Young of *Helix aspersa*. (Slightly enlarged.)

from adults only in size and frailty of shell. They usually remain in the nest from 2 to 4 days before working their way out through the mixture of soil and mucus with which the adult closed the opening. Upon leaving the nest, the young feed upon the first suitable tender plants with which they come in contact.

From the time of hatching, the size of the shell is gradually increased, except during times of dormancy, to accommodate the growing body. The calcareous substance forming the shell is secreted by the mantle and deposited across the front in thin layers, gradually lengthening and broadening the form as growth proceeds. As the shell becomes larger, it is also made thicker by deposits from the mantle all over the inside. Snails that have their shells broken can mend them to a remarkable degree. New shell is built over places where sections of shell have become detached, but the original markings are not reproduced (fig. 8). Newly-formed shell is very fragile and semi-transparent on young snails. It requires about two years

for this species to grow to maturity. Table 5 shows the comparative size, by whorls, of snails at different ages.

The snails one year old, noted in table 5, were distinctly smaller than the mature specimens and possessed thinner shells. Their shells were from 16 to 20 millimeters in diameter, whereas the shells of the mature snails ranged from 26 to 33 millimeters in diameter.



Fig. 8.—Snails that have repaired their broken shells. (Slightly enlarged.)

TABLE 5

COMPARISON OF THE NUMBER OF WHORLS IN SNAILS OF DIFFERENT AGES AT FULLERTON, 1929

Age	Number of whorls	Number of specimens
5 days.....	1 $\frac{1}{3}$	2
	1 $\frac{1}{2}$	15
	1 $\frac{2}{3}$	16
	1 $\frac{3}{4}$	2
1 year.....	3 $\frac{1}{3}$	4
	3 $\frac{1}{2}$	1
	3 $\frac{2}{3}$	1
Large adults.....	4 $\frac{1}{4}$	3
	4 $\frac{1}{2}$	13
	4 $\frac{1}{2}$	5

The food of *Helix aspersa* consists of either living plants or dead or decayed vegetation, and they probably get some nourishment from the organic matter in the soil which is commonly taken into the alimentary tract. The dead bark of twigs is frequently eaten, and also paper that happens to be near their haunts. The paper tags (fig. 9) on some outdoor breeding cages were almost completely eaten by

snails on the outside of the cages, even though they had free access to a variety of plants. Growing plants, however, furnish the major portion of their food, and for this reason they are pests in gardens, nurseries, and orchards. Lettuce, cabbage, begonia, dahlia, canna, and orange are only some of the plants of which they are fond. Since snails are also very fond of ground wheat and corn, these substances are used in the preparation of poison baits for their control.



Fig. 9.—Paper tags partly eaten by snails.

BEHAVIOR

The species is distinctly nocturnal. Occasional individuals may be seen moving about during the daytime, but they are the exception, for most snails leave their hiding places after dark and retreat before daybreak. The fact that snails are frequently found in coition or oviposition during the day is not a sign of diurnal habits, as these operations require a number of hours for completion, and are started during the night. If a snail begins to dig a nest during the night, it continues through the following day until the nest is completed and the eggs laid.

The snails infesting the garden and shrubbery about a home in Fullerton offered excellent opportunities for observations of their activities. Many snails utilized the ferns along the side of the house for their retreat. From these ferns, during favorable weather, they crawled out nightly (table 6) onto the lawn for a distance of 8 to 12 feet to feed on the grass. Usually at night, one could not walk over the lawn in the vicinity of the fern beds without crunching snails

TABLE 6

OBSERVATION ON THE NOCTURNAL AND DIURNAL ACTIVITY OF *HELIX ASPERSA*
AT FULLERTON, 1929

Date	Time	Note
June 28	9:00 P.M.	Many snails out on lawn
June 29	8:00 A.M.	No snails out
June 30	10:00 P.M.	Many snails out
July 1	7:00 A.M.	Very few snails out although weather damp and foggy
July 1	9:00 P.M.	Many snails out
July 2	5:00 A.M.	Very few snails out; daylight, damp, foggy



Fig. 10.—Dormant snails sealed to each other during unfavorable conditions.

under his feet. However, in the morning, all but a few stragglers had returned to the ferns, where they remained hidden all day, regardless of temperature or humidity.

In California, the most important factor affecting the seasonal activity of *Helix aspersa* is low humidity, as snails become inactive when dry conditions prevail. Such conditions may continue for days, weeks, or even months, during which time they seal themselves fast to various objects or close the opening of the shell with a parchment-like epiphragm (fig. 10). Upon the resumption of more humid conditions the snails again become active.

During 1929 at Fullerton, the European brown snail was active nightly from June 9⁴ until October 20; from the latter date to January 5 there was practically no activity. During this period of inactivity, low humidity generally prevailed. There was no rain and there were very few foggy nights until January 5, when rain fell during the night and on the day following. On the night of January 6 at 8:00 P.M., snails began crawling onto the lawn. From January 6 to January 20 inclusive, either rainy or damp weather prevailed and there was some activity nightly, although not so much as during



Fig. 11.—The snail on the right is in a state of hibernation, and has the opening closed with an epiphragm. The one on the left is active and has withdrawn its body into the shell.

warmer weather. On January 21 it was clear and windy, and low humidity again prevailed until rain fell on January 26. During the period from January 21 to January 26 inclusive, there was no activity. On the night of January 27, following the rain on January 26, a fair number of snails were out, and on January 28 there was more activity than there usually is at this time of the year.

The temperature range of activity extends from about 40° to 71° Fahrenheit night temperatures, although the absolute upper and lower limits were not determined. Lowe⁽⁴⁾ states that *Helix aspersa* survived a temperature of 14° F, which killed several different species of slugs.

During the winter months and extending late into the summer, a certain percentage of snails bury themselves in loose soil to a depth

⁴ They were active prior to June 9, but this date marks the beginning of these regular observations.

of $\frac{1}{4}$ to $\frac{1}{2}$ inch below the surface and seal the opening of the shell with an epiphragm (fig. 11). They remain dormant in this state of hibernation for an indefinite period. At Fullerton on January 25, 1927, in a population (table 7) of 755 snails on and around an orange tree, 79 snails, or slightly more than 10 per cent, were in hibernation. The dormancy induced by dryness is a temporary protection against external conditions and may last a few days or weeks, and ends when favorable conditions again prevail. Hibernating snails remain dormant for a time under California conditions even though the temperature and humidity are fully satisfactory for the majority. In such localities as Maine and Nova Scotia, all of the individuals no doubt pass the winter months in hibernation.

ECONOMIC IMPORTANCE

Helix aspersa has some value as an article of food in European countries, although another species, *Helix pomatia*, exceeds it in popularity as a table delicacy. In California it is not eaten, except by an occasional European immigrant.

The presence of snails in large numbers about a residence is objectionable, aside from the damage done to gardens, because they crawl about on lawns and walks during the night, where one is likely to step on them.

Their damage to plants may or may not be of economic importance. It may be negligible if they are feeding mostly on weeds. On lawn grass, also, their feeding only shortens the grass, and since it is cut short anyway, the appearance of the lawn is not affected. At the residence in Fullerton, hundreds of snails hid in clumps of ferns during the daytime and fed on the lawn nightly, but since ferns are not a suitable food plant, and since they fed only on the lawn, there was no damage beyond their presence as a nuisance.

If snails feed on cultivated plants, on the other hand, they may be very injurious, especially to young, tender plants in vegetable and flower gardens. Frequently, enormous populations become established in citrus groves, and do considerable damage to leaves and fruit. Infested trees can be detected even before the snails are seen because of the riddled appearance of the foliage (fig. 12). Much damage may be done to the fruit (fig. 13), especially during rainy weather, when even the slightest injury to the skin gives entrance to decay organisms.



Fig. 12.—Orange leaves showing damage by *Helix aspersa*.



Fig. 13.—Oranges damaged by snails.

Growers have stated that these snails also peel the bark from green twigs, causing dead wood in the infested trees. The author has never been able to substantiate this with his own observations, but they do commonly peel the bark from twigs already dead (fig. 14).

In citrus groves, the snails lay their eggs in the uncultivated portions of the ground around the trees. Because of regular irrigations and the presence of a leaf mulch under the trees, conditions are usually more or less suitable, aside from temperature and humidity,

for reproduction the year round. During times of activity, the snails migrate back and forth from the ground to all parts of the trees, including the outermost and topmost branches. When daylight



Fig. 14.—Dead twigs from an orange tree, showing where snails have been feeding on the bark.

appears, they remain inactive wherever they may be—on twigs, leaves, fruit, or on the ground. When conditions of low humidity prevail, the snails congregate in large numbers on the trunk (fig. 15) where they seal themselves fast and remain inactive until the resumption of more humid conditions.

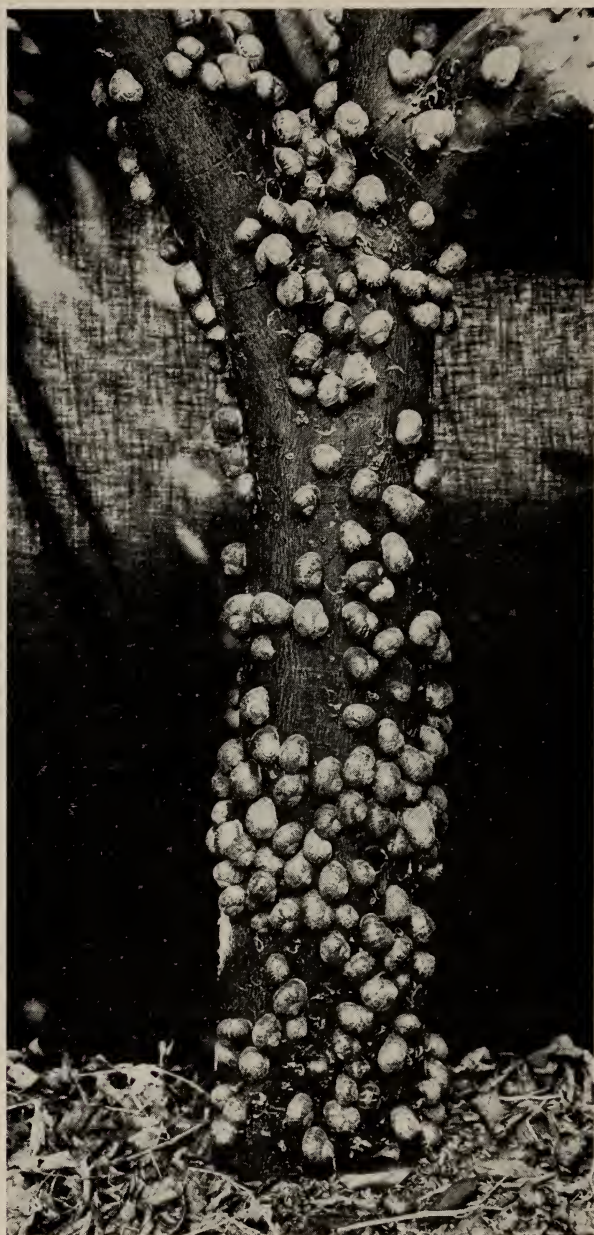


Fig. 15.—*Helix aspersa* fastened to the trunk of an orange tree during dry weather conditions.

The number of snails in heavy infestations reaches hundreds per tree. For example, a tree of average infestation in a grove in Fullerton on February 9, 1927, had a total snail population of 755, as shown in table 7.

CONTROL

The principal methods used in controlling the European brown snail are the use of contact poisons or irritants, hand-picking, and poison baits.

The use of contact materials, such as salt, lime, and certain proprietary preparations, is not thoroughly satisfactory because the snail must either get enough of the poison or irritant on its body to kill it, or it must crawl into the substance. Snails are very cautious and will not crawl into an irritating material if it can be avoided. Such poisons or irritants, however, can be used successfully as barriers to prevent snails from going up trees or crawling to certain protected spots.

Hand-picking is rather laborious, but very effective. If the daytime retreats are discovered, or the hand-picking is done during the night, many snails can be destroyed. However, the younger snails are usually missed in this operation. During times of low humidity, when it is too dry for the snails to be active, good results can be obtained in infested citrus groves by picking the snails from the trunks of the trees where most of them are sealed fast.

By far the most effective control is obtained with poison baits. A bait composed of 1 part calcium arsenate and 16 parts of wheat bran has proved very satisfactory. The two materials are mixed dry and then enough water is added to make a moist but not wet mash. It should not form into a ball when squeezed with the hand. This mixture is then scattered in small particles, as in broadcasting grain, where the snails are most likely to find it. In gardens it should be scattered on the ground around the plants attacked, as well as around the bushes and places where the snails secrete themselves during the daytime. In citrus groves it is scattered on the ground around the trees as far as the foliage extends, but not in the intervening space between the trees. Snails of all ages feed readily on this bait and it is effective for many days unless washed away or otherwise dissipated by heavy rains or irrigation. This bait was first used against the white snail, *Helix pisana*,⁽¹⁾ in San Diego County. The European brown snail was also present in much of the territory treated for the white snail, and was equally well controlled. Satis-

factory poison baits for snails may also be purchased from dealers in insecticides.

The use of poison baits should be restricted to the times of the year when the greatest number of snails are active. The most favorable seasons for control are the spring and summer months during

TABLE 7

RESULT OF TREATMENT OF ONE ORANGE TREE WITH BRAN AND CALCIUM
ARSENATE IN A GROVE AT FULLERTON DECEMBER 12, 1926;
DATA TAKEN JANUARY 25, 1927

	Dead	Alive	Per cent kill
Young.....	379	3	99.21
Old.....	283	11	96.26
Adults in soil hibernating.....	0	79	0.00
Total.....	662	93	87.68



Fig. 16.—Mixing snail poison for field treatment.

rainy weather or at times when fogs prevail nightly. However, where water is available about residences, gardens, and nurseries, and the infested areas can be lightly sprinkled each evening for 3 or 4 days after the application of the bait, the snails will be kept active and good results can be obtained at almost all seasons except during freezing weather. A few individuals are likely to be dormant at almost any time of the year. An examination of table 7 shows that

in the December and January treatment, 79 snails, or 10.46 per cent, were in hibernation and thus escaped. Of the 676 active snails only 14, or 2.07 per cent, were alive on January 25.

For field treatment in citrus groves, it was found that 4 pounds of bran and 4 ounces of calcium arsenate were sufficient to treat the area underneath 5 trees abundantly. The limbs and foliage of these trees spread over an area about 12 to 14 feet in diameter. On this basis, 64 pounds of bran and 4 pounds of calcium arsenate would be sufficient to treat an acre of 80 trees. The time required can be estimated from a known application during which two men treated 11 acres having 1,100 trees, in 12 hours. That would be approximately 45 trees per hour per man, or about 2 hours per acre per man.

Only small quantities are necessary for home gardens. Four pounds of bran and 4 ounces of calcium arsenate would be sufficient for the infested places on the average lot. When the material is to be prepared in large quantities, a mixing box (fig. 16) should be used, and the scattering done from buckets or bags hung on the shoulders.

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